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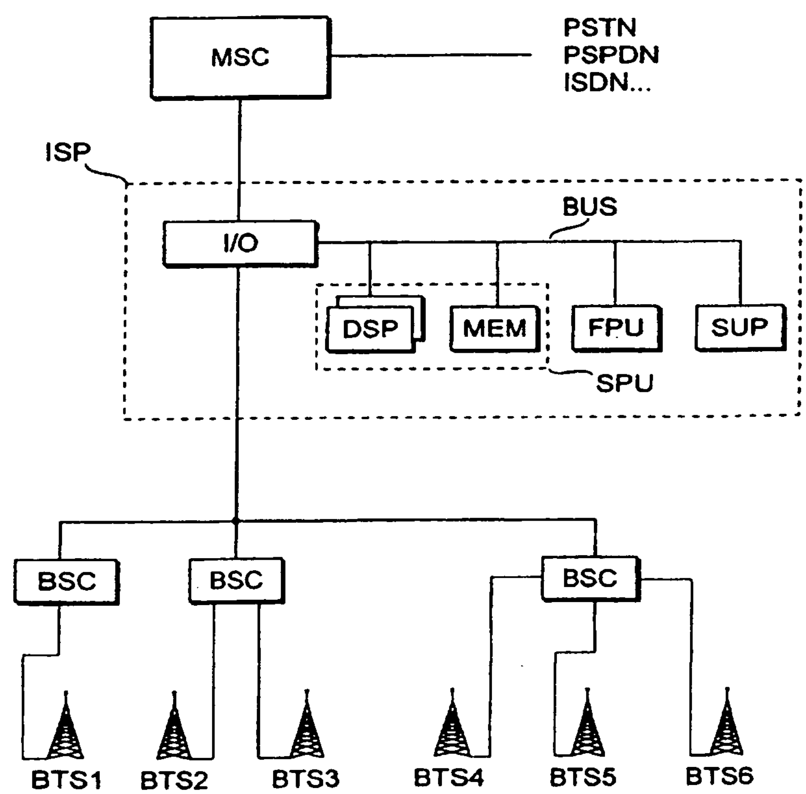
(54) Title: INTERGRATED SPEECH ENCODING

(57) Abstract

In prior art mobile communication systems, a speech signal is processed and converted from one format to another at several points. Such conversions include Echo Cancellation (EC), Transcoding (TC), and Soft Handover (SH) with Diversity Combining (DC). These measures for processing the signal and for converting it from one format to another at several points of the system to a great extent include analogous processing. A consequent problem is met that carrying out analogous processing for a multitude of times at several different points adds to the complexity of the system, increases costs and deteriorates the reliability of the system. Processing steps carried out separately are only able to utilize results of the preceding processing step, but are not able to utilize useful intermediate results. According to the invention, as many as possible of the processing steps of the mobile communication system are carried out in an integrated network element (ISP, Integrated Speech Processing), which may be a separate unit. The ISP unit may physically be located also at a Mobile Switching Center MSC. Integrated processing provides the advantages of a simpler structure as all the processing steps may be carried out by the same signal processor (DSP). Integration reduces costs and makes the system more reliable. The integrated network elements (ISP) according to the invention may also be placed in parallel either at the same point or as part of Base Station Controllers (BSC).



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INTEGRATED SPEECH ENCODING

The invention relates to an arrangement according to the preamble of claim 1 for integrating the functions of mobile communication systems.

Figure 1 shows, from the point of view of the invention, the essential parts of a cellular mobile communication system. Mobile stations (MS) communicate with base transceiver stations (BTS). The base stations are controlled by base station controllers (BSC) which are connected via transcoders (TC) to mobile switching centers (MSC). A subsystem under control of a base station controller BSC, including the base stations BTSn it controls, is commonly referred to as a base station subsystem (BSS). The interface between the mobile switching center MSC and the base station subsystem BSS is referred to as an A-interface. The part of the mobile communication system at the MSC side of the A-interface is referred to as a network subsystem (NSS).

The mobile switching center MSC handles the connecting of incoming and outgoing calls. It performs functions similar to those of an exchange of a public switched telephone network (PSTN). In addition to these, it also performs functions characteristic of mobile communications only, such as subscriber location management, jointly with the subscriber registers of the network. As subscriber registers, the GSM system at least includes a home location register HLR and a visitor location register VLR, not shown. The mobile switching centers MSC are connected to other networks, such as the public switched telephone network PSTN and/or an integrated services digital network ISDN, etc.

In the prior art mobile communication system described above, a speech signal is processed and converted from one format to another at several different points.

Echo cancellers (EC) prevent an echo returning from the PSTN from reaching a mobile subscriber. In a mobile switching center, the echo cancellers are usually placed in connecting lines between the mobile switching centers.

The transcoders TC convert speech from a digital format to another. Traffic between the center and the transcoder TC may be e.g. PCM data encoded in the form of 64 kbit/s A-law. Alternatively, encoding according to the μ-law may be employed. The traffic between the transcoder TC and the base station controller BSC may be encoded speech of 13 kit/s. Rate adaptation for

the data is carried out between the rate of 64 kbit/s and the rates of 3.6; 6 or 12 kbit/s.

A soft handover (SH) with diversity combining (DC), i.e. macrodiversity, may be carried out e.g. as follows. In the downlink direction, the signal is conveyed to the mobile station via several base stations BTS, and in the uplink direction, signals from the mobile station MS are received via several base stations BTS. In the receiver, speech frames are combined e.g. by choosing, according to a particular criterion, the best of the speech frames received via the different routes. Suitable criteria to be used include SINR (Signal to Interference plus Noise Ratio) and bit error rate (BER). This function is activated by the mobile switching center MSC (or the base station controller BSC) after having found out that the mobile station has roamed to a service area jointly covered by two or more base stations BTS.

In Figure 1, arrows in the form of broken lines illustrate that processing steps relating to SH and DC are carried out at points indicated by the arrows - not necessarily at every point.

The aforementioned procedures for processing the signal and converting it from one format to another at several points of the system contain much of analogous processing. In such a mobile communication system, the problem is encountered that carrying out analogous processing many times at several points of the system adds to the complexity of the system. The increased complexity results e.g. from the fact that every point of the system where aforementioned processing steps are carried out requires separate signal processors, memories, etc. The processing steps carried out separately are only able to utilize results of the preceding processing step but they are not able to utilize useful intermediate results. The added complexity increases costs and makes the system less reliable.

It is consequently an object of the present invention to develop an arrangement which is applicable to a mobile communication system and which comprises the aforementioned processing steps so that problems associated with the complexity, price and reliability of the system can be solved. The objects of the invention can be achieved by means of an arrangement which is characterized by what is set forth in the independent claims. The dependent claims relate to the preferred embodiments.

The invention is based on the idea that as many as possible of the processing steps of a mobile communication system are carried out in an

integrated manner, advantageously in one integrated network element. Such an integrated network element may be a separate unit, which within the network hierarchy is located in place of a transcoder 1 according to Figure 1. The integrated network element may physically also be located at the MSC, but with clearly defined areas of responsibility according to the A-interface for the hardware manufacturers. The arrangement of the invention provides the advantage of a simpler structure over the prior art solution, which reduces costs and increases the reliability of the system. The invention is characterized by vertical integration, i.e. integration of different functions. In order to increase signal processing capacity, it is advantageous to place several signal processors in parallel. It is also possible to place, in parallel, several integrated network elements according to the invention either so that they are located at the same point, or alternatively as part of e.g. the base station controllers BSC. Thus, the terms to use side by side in association with the invention are vertical integration, i.e. integration of functions, and horizontal distribution.

Advantages relating to synergy are the greatest if the integrated network element according to the invention is arranged to carry out processing steps associated with as many as possible of the functions. However, it may in some cases be justifiable to leave some of the functions, such as echo cancellation, to be performed by a separate unit and to combine the other functions into an integrated network element, which may be separate or part of e.g. the base station controller BSC.

In principle, it could be contemplated to integrate all the functions to the NSS side of the A-interface, that is, to the MSC side. Such a change would require, at least in the GSM system, changes of such magnitude that one could hardly use the term GSM any more.

In the following, the invention will be described by means of the preferred embodiments with reference to the attached drawings, in which

Figure 1 shows, from the point of view of the present invention, the essential parts of a mobile communication system;

Figure 2 illustrates the preferred embodiment of the invention and an exemplary structure of the integrated speech encoding unit according to the invention; and

Figure 3 is a flow chart representation of how the exemplary integrated speech encoding unit works.

Referring to Figure 2, transcoding TC, echo cancellation EC, soft handover SH and/or macrodiversity DC are integrated in a network element referred to as an Integrated Speech Processing (ISP) block. The I/O (Input/Output) block comprises all the interfaces to the uplink and downlink transmission paths, including multiplexers and demultiplexers, which are not shown. The I/O block may be of prior art technology. The functions according to the invention may be implemented by e.g. digital signal processors DSP, which are connected to a memory MEM via a bus BUS. For reasons of efficiency, the bus BUS is advantageously a parallel bus. To obtain horizontal distribution, i.e. an adequate processing capacity, there are usually a plurality of signal processors DSP. As all the signal processors DSP have access to the common memory MEM, it is not imperative to carry out the processing steps associated with one speech or data connection by one and the same signal processor DSP, but a new task may be assigned to a subsequent processor that is free.

The same memory MEM may also contain speech Frame Processing Unit (FPU) which may, depending on the hardware provider's architecture, be constructed using wired logic or a digital processor with suitable software. Support (SUP) circuits comprise all the support circuits that are essential to the operation of the processors, such as clocks, interrupts, power supply, etc. A speech processing unit SPU consists of the signal processor DSP and its software stored in the memory MEM.

In an arrangement according to Figure 2, a processing block ISP carries out tasks that according to prior art are comprised by the functions TC, EC, SH and DC.

The basic task of the transcoding TC is to convert speech samples between formats encoded according to e.g. A-law and those encoded in some other manner.

Echo cancellation EC may take place e.g. as follows. A speech sample is encoded in the form of A-law; speech thus encoded is transmitted to the MSC; in addition, the encoded speech is stored in the memory MEM from which the speech processing unit SPU may retrieve it when needed; when the same speech sample comes back to the transcoder TC from the direction of the MSC, the speech processing unit SPU retrieves the sample corresponding to the speech frame in question from the memory MEM, and on the basis of the sample it cancels, from the downlink speech frame, a signal

detected to be an echo. The speech processing unit SPU consists e.g. of a digital signal processor DSP with its peripheral devices. The memory MEM comprises at least Random Access Memory (RAM), but for storing software it may also contain Read Only Memory (ROM) and/or flash memory, a hard disk etc.

For the soft handover SH and diversity combining DC, the processing block ISP has at its disposal several samples that have arrived along alternative paths. In an urban area, where the highest interference levels are met, the number of base stations audible simultaneously is also normally higher than outside of towns. According to prior art, the best of the speech frames is chosen by a specific criterion. In order to choose a frame, the invention provides the alternative that also parts of several frames may be combined, which results in that a frame will be obtained which is better than any single frame. By combining several frames it is hence possible to form a signal with a quality better than that of a signal which could have been formed from just one input signal.

Figure 3 shows exemplary processing steps when diversity combining DC and echo cancellation EC are being carried out in the circuit according to Figure 2. In Figure 3, an index i refers to successive samples of speech frames and N refers to parallel diversity branches. The reference mark P refers to a counter by means of which it is ascertained that all the diversity branches will be examined. An index j and the stored samples EC are related to echo cancellation.

At steps 302-1...302-N samples are formed from speech signals 1...N. At steps 304-1...304-N the samples are stored in the memory into addresses 1...N. At steps 306 - 308 it is determined whether all the parallel processes have been examined, and if that is the case, the samples will be processed by signal processors DSP at step 310. At step 312, the process starts anew with the next sample.

A possible implementation for the processing step 310 is described as steps 320 - 336. At step 324, the sample 1...N, stored at step 304, is read out from the memory 1...N. At step 326, result information is formed e.g. so that the frame processing units FPU of the processing block ISP receive corresponding samples of speech frames and store them in the memory MEM. The speech processing unit SPU forms, from the samples stored in the memory MEM, a signal according to A-law (or correspondingly μ-law). At step

328, the echo information EC is stored in the memory and the signal is transmitted to the connecting line. At step 334, echo cancellation is carried out by a suitable algorithm. At step 336, the sample is transmitted to the subscriber.

When combining functions of the transcoder TC and the echo canceller EC it should be noted that these functions are conventionally carried out at different sides of the A interface, i.e. possibly at areas of responsibility of different hardware manufacturers. In addition, it is possible that under control of the MSC a call is connected between two phones that perform echo cancellation independently. This would mean carrying out echo cancellation twice, which would deteriorate signal quality. These matters may be taken into account by an appropriate negotiation procedure in which connection-specific negotiations may be held as to e.g. whether echo cancellation should be used on the connection or not.

Integration of the speech encoding according to the invention may also be carried out also incompletely. In such a case, e.g. echo cancellation may be left to be carried out by a separate unit, and the integrated network element ISP may be arranged to carry out processing steps related to the other functions TC, SH and DC. The integrated network element ISP may be implemented as a separate unit which as regards signal propagation is located in place of the prior art transcoder TC. Physically, the integrated network element ISP may be installed as an independent unit, or it may be placed in the same space with the MSC. Alternatively, the integrated network element ISP may be installed at every BSC. Such a solution may be desired in a case in which, in order to increase computing capacity, digital processing is to be distributed horizontally, e.g. because it is not desired or possible to implement a network element efficient enough to process all the traffic of the center MSC.

It is obvious for a person skilled in the art that the basic idea of the invention may be implemented in various ways. So-called third generation mobile communication systems are intended to be the primary targets of implementation, particularly when employing CDMA radio technology in which it is natural to utilize macrodiversity. However, the invention may, where applicable, also be used in connection with existing systems, such as the GSM/DCS. The invention and its embodiments are therefore not restricted to the examples described above but they may vary within the scope of the claims.

CLAIMS

1. An arrangement for integrating the functions of a mobile communication system, such functions comprising at least transcoding (TC), echo cancellation (EC), and a soft handover (SH), advantageously also diversity combining (DC), **characterized** in that in order to utilize the similarity of the processing tasks of the different functions (TC, EC, SH, and DC), processing steps associated with at least three of said functions are carried out by the same digital signal processor (DSP).

2. An arrangement as claimed in claim 1, **characterized** in that at least some of the different functions (TC, EC, SH, DC) utilize intermediate results of the other functions.

3. An arrangement as claimed in claim 1 or 2, **characterized** in that processing steps (TC, EC, SH and DC) associated with all the functions are carried out by the same digital signal processor (DSP).

4. An arrangement as claimed in claim 1 or 2, **characterized** in that several digital signal processors (DSP) have been installed in parallel in order to increase the processing capacity, and each of the processors (DSP) carry out all functions (TC, EC, SH and DC) that take place in the arrangement.

5. An arrangement as claimed in any one of claims 1 - 4, **characterized** in that the functions include a soft handover and diversity combining (DC), and that at least at some of the speech frames an output signal is formed by combining parts of several speech frames received over different paths.

6. An integrated network element (ISP) for a mobile communication system whose functions comprise at least transcoding (TC), echo cancellation (EC), and soft handover (SH), advantageously diversity combining (DC) as well, with the network element (ISP) comprising a means (I/O) for connecting to a connecting line, a means (FPU) for processing speech frames, memory (MEM) for storing the signal samples, and at least one digital signal processor (DSP), support circuits (SUP) and a bus (BUS) combining the parts, **characterized** in that at least one digital signal processor (DS) is arranged to carry out processing steps associated with at least three functions (TC, EC, SH and DC) of the mobile communication system.

7. An integrated network element as claimed in claim 6, **c h a r a c t e r i z e d** in that it comprises several digital signal processors (DSP) that have a connection to the memory (MEM) via the bus (BUS)

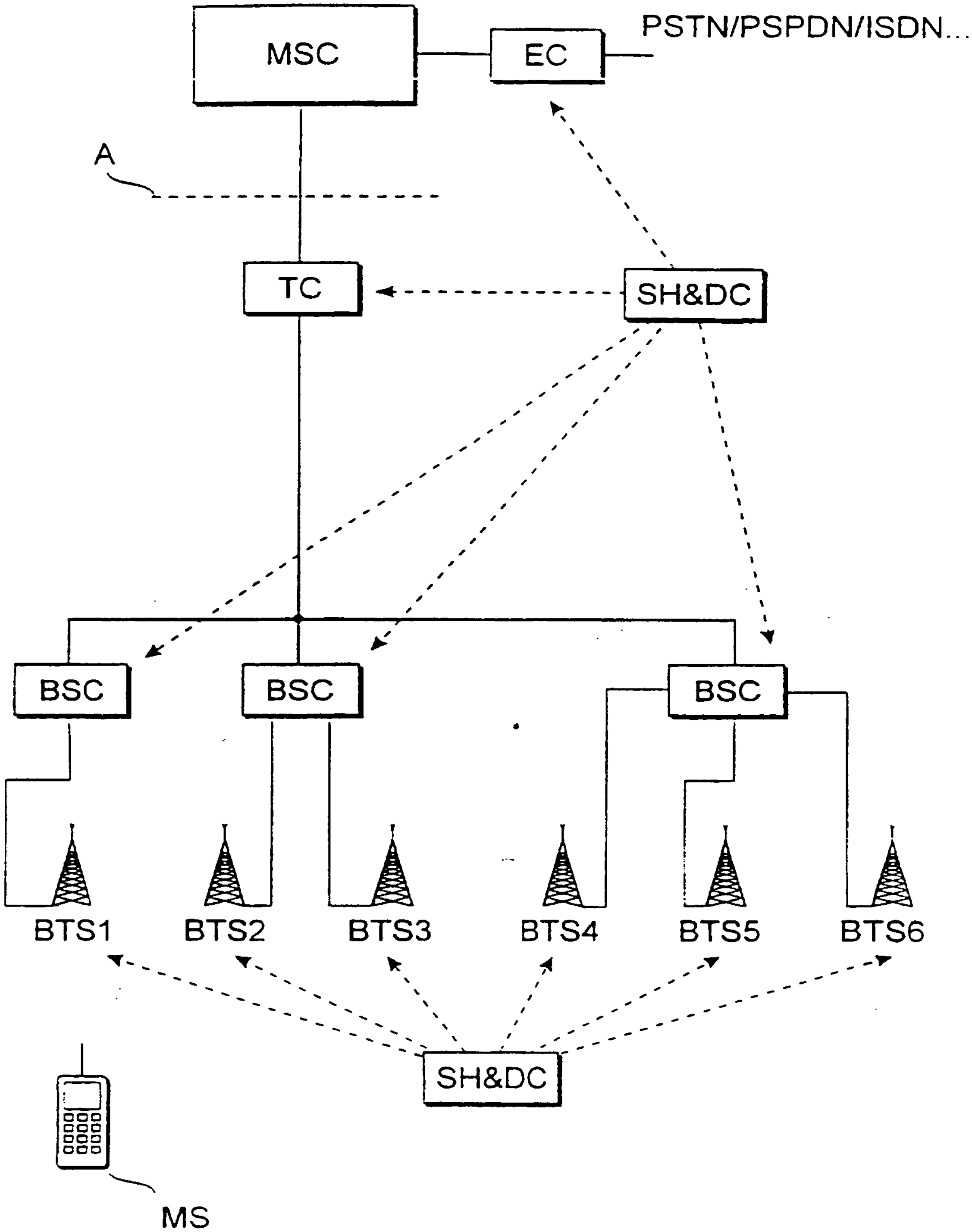
8. An integrated network element (ISP) as claimed in claim 6, **c h a r a c t e r i z e d** in that it is placed at a mobile switching center (MSC) of the mobile communication system.

9. An integrated network element (ISP) as claimed in claim 6, **c h a r a c t e r i z e d** in that it is placed at a base station controller (BSC) of the mobile communication system.

10. A mobile communication system, **c h a r a c t e r i z e d** in that it comprises at least one integrated network element (ISP) according to claim 6.

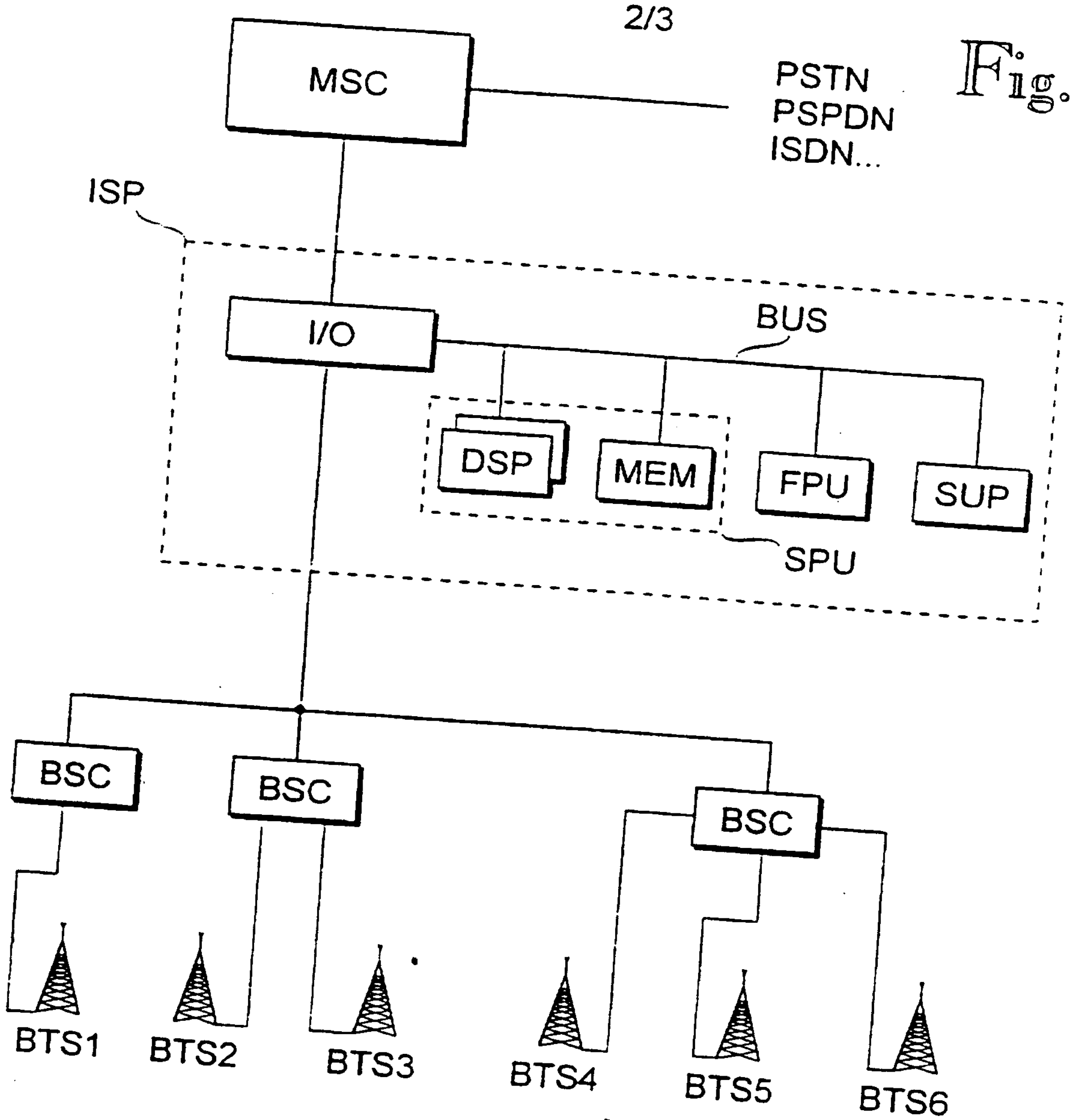
11. A mobile communication system, **c h a r a c t e r i z e d** in that it comprises a number of integrated network elements (ISP) according to claim 6.

Fig. 1



MSC
EC
PSTN/PSPDN/ISDN...
A
TC
SH&DC
BSC
BSC
BSC
BTS1
BTS2
BTS3
BTS4
BTS5
BTS6
SH&DC
MS

Fig. 2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ISP
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BUS
DSP
MEM
FPU
SUP
SPU
BSC
BSC
BSC
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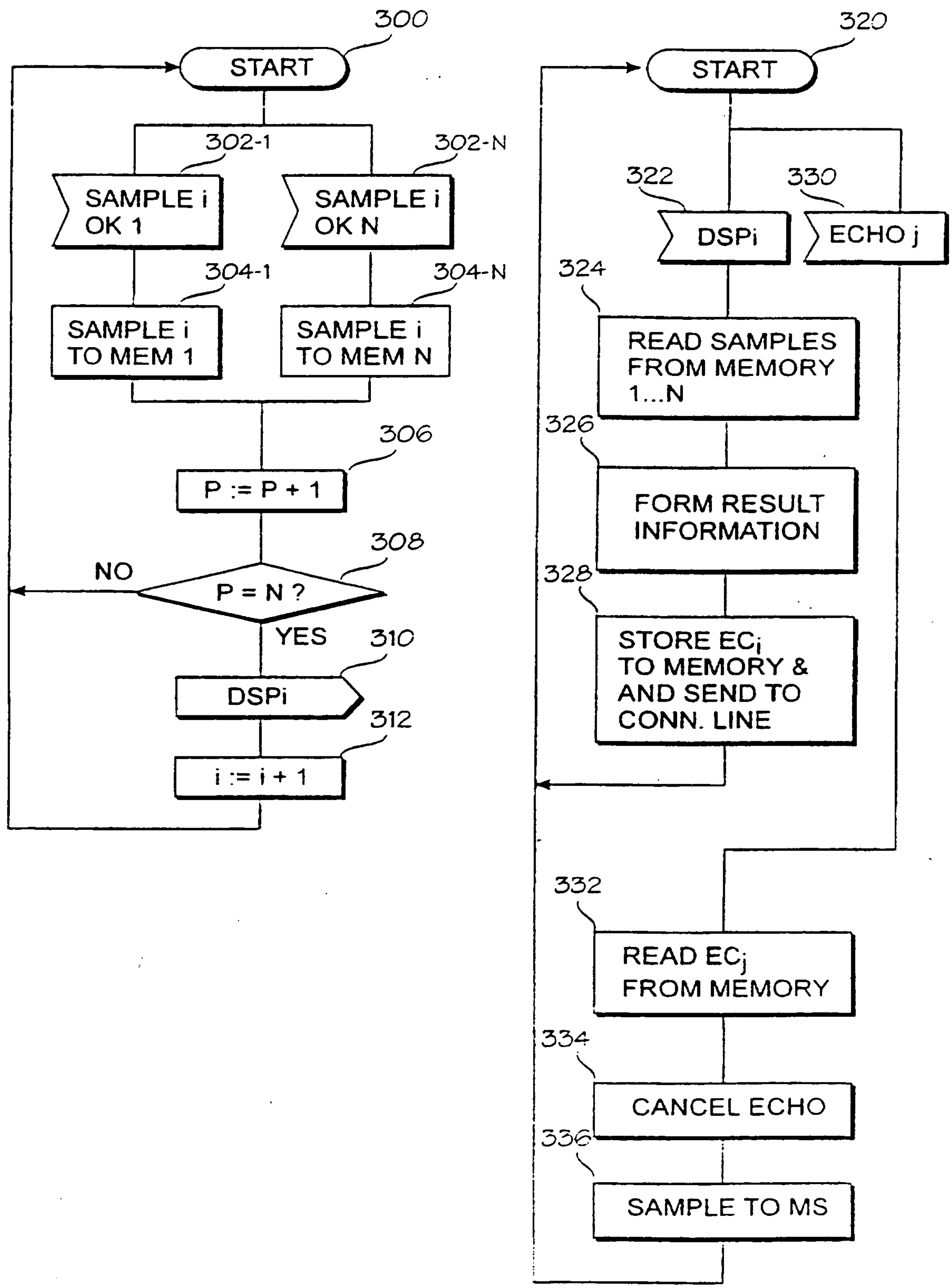
BTS5
BTS6

Fig. 3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SAMPLE i
OK 1
302-N
SAMPLE i
OK N
304-1
SAMPLE i
TO MEM 1
304-N
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TO MEM N
306
P := P + 1
308
NO
P = N ?
YES
310
DSPi
312
i := i + 1
320
START
322
DSPi
330
ECHO j
324
READ SAMPLES
FROM MEMORY
1...N
326
FORM RESULT
INFORMATION
328
STORE ECi
TO MEMORY &
AND SEND TO
CONN. LINE
332
READ ECj
FROM MEMORY
334
CANCEL ECHO
336
SAMPLE TO MS

International application No.
PCT/FI 97/00060

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/22

According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, G06F, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0544532 A2 (FUJITSU LIMITED), 2 June 1993 (02.06.93), claim 1, abstract --	1-11
Y	US 4841437 A (ANDRE LUBARSKY ET AL), 20 June 1989 (20.06.89), column 2, line 6 - line 23; column 3, line 40 - line 58 --	1-11
Y	WO 9535636 A1 (GTE LABORATORIES INCORPORATED), 28 December 1995 (28.12.95), page 10, line 34 - line 35, figure 4 --	1-11
A	US 5475689 A (STANLEY KAY ET AL), 12 December 1995 (12.12.95), see whole document -- --------	1-11

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INTERNATIONAL SEARCH REPORT
Information on patent family members

03/06/97

International application No.
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